

**WHAT IS CLAIMED IS:**

1. A process of making crumb and powder rubber comprising:
  - (a) chilling a preprocessed stream of used rubber particles having a predetermined particle size range with a cryogenic fluid wherein the final chilled temperature of the particles is controlled;
  - (b) grinding said stream of chilled rubber particles wherein said particle size distribution of said ground rubber particles is controlled; and
  - (c) screening said ground particle stream into desired crumb and/or powder rubber particle size ranges.
2. A process in accordance with Claim 1 wherein said used rubber particles are particles of used vehicle tires.
3. A process in accordance with Claim 2 comprising (i) granulating an initial charge of rubber particles after removal of any tramp metal; (ii) removing ferrous metal from said granulated particles; and (iii) concurrently screening and removing fiber from said granulated particles prior to said step (a).
4. A process in accordance with Claim 3 comprising removing ferrous metal and fiber from said screened particles subsequent to said step (iii) but prior to said step (a).
5. A process in accordance with Claim 4 wherein said fiber removing steps comprise agitating said rubber particle and aspirating lower density fiber from higher density rubber particles.
6. A process in accordance with Claim 1 wherein said control of particle size temperature in step (a) includes control of duration of contact of said rubber particles with said cryogenic fluid.

7. A process in accordance with Claim 6 wherein said control of rubber particle size temperature includes volumetric flow rate control of said cryogenic fluid contacting said rubber particles.
- 5     8. A process in accordance with Claim 1 wherein said control of particle size distribution in step (b) comprises varying impact surface speed.
9. A process in accordance with Claim 8 wherein said control of particle size distribution further comprises varying the space between said impact surface and a rebound surface.
- 10     10. A process in accordance with Claim 7 wherein said cryogenic fluid is liquid nitrogen.
- 15     11. A process in accordance with Claim 1 wherein said ground stream of cryogenically cooled rubber particles after said step (b) are dried to ambient temperature.
12. A process in accordance with Claim 2 wherein said ground stream of cryogenically cooled rubber particles after said step (b) are dried and fibers present in said ground stream are removed.
- 20     13. A process in accordance with Claim 12 wherein ferrous metal and fibers in said dried stream of rubber particles are removed.
- 25     14. A process in accordance with Claim 13 wherein said rubber particle stream from which ferrous metal and fiber are removed is screened to remove rubber particles whose particle size exceeds the maximum particle size of crumb rubber and wherein more fiber is removed.
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15. A process in accordance with Claim 14 wherein said particles from which excess sized particles are removed is screened into three rubber particle sizes within the particle size range of crumb and powder rubber.

5 16. A process in accordance with Claim 15 wherein said rubber particles include a first particle size range of particles passing through U.S. sieve size No. 40 but not passing through U.S. sieve size No. 80; a second particle size in the range of between particles passing through U.S. sieve size No. 80 but not passing through U.S. sieve size No. 140; and a third particle size of particles passing through U.S. sieve size No.  
10 140.

17. An apparatus for making crumb and powder rubber comprising:  
chilling means for cooling a preprocessed stream of used rubber particles having a predetermined particle size range provided with means for introducing said  
15 preprocessed stream of used rubber particles and a cryogenic fluid whereby said rubber particles are cooled to a predetermined temperature;  
grinding means for grinding said cooled rubber particles at said predetermined temperature to a predetermined particle sized range; and  
screening means for separating said ground rubber particles into desired crumb  
20 and/or powder rubber particle size ranges.

18. An apparatus in accordance with Claim 17 wherein said used rubber particles are used vehicle tire particles.

25 19. An apparatus in accordance with Claim 17 comprising metal detection means for removing tramp metal present in an initial charge of used rubber particles; primary granulation means for granulating said initial charge; a first ferrous metal removing means provided with means for fiber removal for removing ferrous metal and fiber from said granulated rubber; and a primary screening means provided with fiber  
30 removal means for screening said granulated particles, all of said means disposed upstream of said chilling means.

20. An apparatus in accordance with Claim 19 comprising secondary granulation means for granulation of rubber particles that do not pass through said primary screening means; and a preprocessed rubber particle hopper for holding said rubber particles exiting said primary and secondary granulation means.

21. An apparatus in accordance with Claim 20 comprising a second ferrous metal and fiber removal means for removing ferrous metal and fiber from said preprocessed rubber particles exiting said preprocessed rubber particle hopper.

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22. An apparatus in accordance with Claim 21 comprising a third fiber removal means for removing fiber from said rubber particles exiting said second ferrous metal and fiber removal means.

15 23. An apparatus in accordance with Claim 22 comprising a fiber cyclone and baghouse for storage of said removed fiber removed by all said fiber removal means.

24. An apparatus in accordance with Claim 17 comprising an off-specification supersack feeding hopper for introduction of off-specification used rubber particles into a primary screener and fiber removal means wherein said off-specification used rubber particles are screened to remove oversized particles and remove fiber present in said off-specification used rubber particles, said hopper and primary screening and fiber removal means disposed upstream of said cooling means.

25 25. An apparatus in accordance with Claim 17 comprising a preprocessed supersack feeding hopper for introduction of used rubber particles preprocessed to screen out particles larger than sizes within the range of crumb and powder rubber and from which ferrous metal and fiber have been removed; a second ferrous metal and fiber removal means for removal of ferrous metal and fiber from said preprocessed used rubber particles fed from said supersack feeding hopper; and a third fiber removal

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means for removal of fibers from said rubber particles exiting said second ferrous metal and fiber removal means.

26. An apparatus in accordance with Claim 22 comprising a storage bin with metering  
5 discharge for storage of said rubber particles exiting said third fiber removal means and from which said preprocessed used rubber particles are fed into said cooling means.

27. An apparatus in accordance with Claim 17 wherein said cooling means comprises  
10 a cylindrical shaped vessel provided with means for controlled introduction of a cryogenic fluid and for time controlled contact of said preprocessed stream of used rubber particles with said cryogenic fluid.

28. An apparatus in accordance with Claim 27 wherein said time controlled contact is  
15 provided by variable speed auger, disposed in said cylindrical shaped vessel, upon which said rubber particles are disposed.

29. An apparatus in accordance with Claim 18 wherein said grinding means  
comprises means for introduction of said cooled preprocessed rubber particle stream  
20 between a controlled speed impact surface and an outer inverted surface.

30. An apparatus in accordance with Claim 29 wherein said controlled speed impact  
surface is an impact surface provided with a plurality of replaceable knives and said  
outer inverted cone surface has an interior surface, in contact with said preprocessed  
25 steam of rubber particles, comprising a serrated surface.

31. An apparatus in accordance with Claim 30 wherein said outer inverted cone  
surface is movable in a vertical direction wherein volume between said impact surface  
and serrated surface of outer invented cone surface is increased or decreased.  
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32. An apparatus in accordance with Claim 17 including drying means for drying said ground stream of cryogenically cooled rubber particles to ambient temperature.
33. An apparatus in accordance with Claim 32 wherein said drying means is a rotary  
5 dryer provided with a gas entraining stream to separate lower density fiber from higher density rubber particles.
34. An apparatus in accordance with Claim 27 wherein said cryogenic fluid is liquid nitrogen and said cooling means is provided with conduit means for recycle of said  
10 vaporized nitrogen gas resulting from cooling of said rubber particles whereby said vaporized nitrogen gas flows concurrently into said cooling means with said preprocessed rubber particle stream.
35. An apparatus in accordance with Claim 32 comprising a final ferrous metal and  
15 fourth fiber removal means disposed downstream of said drying means for removal of ferrous metal and fiber from said dried rubber particles.
36. An apparatus in accordance with Claim 35 wherein said final ferrous metal and fourth fiber removal means, disposed downstream of said drying means, comprises a  
20 magnetic separator disposed under a vibratory pan screen wherein said ferrous metal is removed below said screen and said fibers are removed above said screen.
37. An apparatus in accordance with Claim 36 comprising a fifth fiber removal means, disposed downstream of said final ferrous metal and fourth fiber removal  
25 means, for removal of fiber from said rubber particles exiting said final ferrous metal and fiber removal means.
38. An apparatus in accordance with Claim 37 wherein said fifth fiber removal means comprises a centrifugal screener wherein light fiber is removed to a fiber cyclone and  
30 baghouse.

39. An apparatus in accordance with Claim 36 comprising a two-deck screening means disposed downstream of said fifth fiber removal means for removal of rubber particles having a size in excess of the size range of crumb and powder rubber.
- 5     40. An apparatus in accordance with Claim 39 wherein said oversized particles are recycled to a storage bin provided with metering discharge, said storage bin being in downstream communication with said cooling means; and said particles passing through said two-deck screening means are conveyed to a three-deck screening means.
- 10    41. An apparatus in accordance with Claim 40 wherein said three-deck screening means comprises a top U.S. sieve size No. 80 screen holding particles passing through a U.S. sieve size No. 40 screen, said particles held on said top screen provided with means for transfer to a U.S. sieve size No. 40 to No. 80 rubber crumb rubber particles storage bin; and a bottom U.S. sieve size No. 140 screen, said particles held on said  
15    bottom screen provided with means for transfer to a U.S. sieve size No. 80 to No. 140 storage bin; said particles passing through said bottom screen provided with means for transfer to a powder rubber storage bin holding particles finer than U.S. sieve size No. 140.
- 20    42. An apparatus in accordance with Claim 41 wherein conveyance into said storage bins is effectuated by pneumatic means.